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FUNDAMENTAL STUDIES OF BLACK CHROME FOR SOLAR COLLECTOR USE

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ABSTRACT

The thicknesses of black chrome plated for various times have been measured from electron photomicrographs and correlated with the solar spectrum absorptance and infrared emittance as calculated from spectral reflectance measurements. The maximum absorptance is reached at an average thickness of 0.5 micrometer. The emittance increases only slightly up to 1.0 micrometer but increases rapidly at thickness above 1.0 micrometer.

INTRODUCTION

The NASA-Lewis Research Center has found that commercially electroplated black chrome can be optimized to give the high visible absorptance and the low infrared emittance required for a solar selective coating (ref. 1). Black chrome is a practical solar selective coating in the sense that it is already widely available in the electroplating industry as a decorative finish and it is very durable. The relationship between the thickness of the black chrome and its solar selective properties was investigated. Black chrome thickness was measured using an electron microscope and the thickness was correlated with the measurements of absorptance and emittance.

PROCEDURE

Harshaw CHROM-ONYX was plated over Harshaw NUSAT nickel for varying lengths of time (ref. 1). The absorptance across the visible spectrum was calculated from measurements of the hemispherical, total-diffuse reflectance made on a Cary-14 spectrophotometer at wavelengths from 0.35 to 2.1 micrometers. The emittance was calculated from measurements of hemispherical,

total-diffuse reflectance made on a Willey-318S spectrophotometer at wavelengths from 2.0 to 15 micrometers.

The thickness measurements were made from transmission electron photomicrographs of replicas shadowed with carbon-platinum at 30° angle. Between 75 and 100 measurements were made of each sample and an average thickness was calculated.

Results and Discussion

Table I gives the average coating thickness, and the corresponding absorptance and emittance of black chrome for various plating times. Average thickness of black chrome is plotted against the plating time in figure 1. There is an initial, relatively rapid increase in black chrome thickness with plating time. This interval extends to a plating time of approximately 2 minutes. After approximately 2 minutes, there is a rapid decrease in the rate at which additional black chrome is deposited. The deposition of the chrome oxide layer increases the electrical resistance and thus depresses the rate of further deposition of black chrome. Figure 1 indicates that this slowdown occurs at a thickness of approximately 1 micrometer.

The absorptance of the black chrome-nickel combination is plotted against the average coating thickness in figure 2. The figure shows that the maximum absorptance is reached at an average thickness of 0.5 micrometer. Comparison with figure 1 indicates that the maximum absorptance is reached during the initial period of rapid rate of deposition of black chrome and before the rate of deposition decreases.

The emittance of the black chrome-nickel combination is plotted against the average thickness in figure 3. The emittance remains at low values of approximately 0.10 until an average thickness of approximately 1.0 micrometer is attained. At thicknesses greater than approximately 1.0 micrometer there is an exponential increase in emittance. Comparison with figure 1 shows that the rapid increase in emittance occurs toward the end of the period of rapid increase of black chrome thickness with plating time.

The information presented shows that there is a conveniently long time interval in the relationship between the changing thickness of black chrome and the changing absorptance and emittance properties. High absorptance is

reached at thicknesses of 0.5 micrometer, but rapid increase in emittance does not commence until a thickness of approximately 1.0 micrometer is attained. This is important in terms of the practical production of solar selective coatings in that it would not require a super critically sharp control of coating time in order to stay within the desired limits of 0.5 and 1.0 micrometer for coating thickness.

REFERENCE

1. McDonald, G.; and Curtis, Henry B.: Variation of Solar Selective Properties of Black Chrome with Plating Time. NASA TM X-71731.

TABLE I. - THICKNESS, ABSORPTANCE, AND EMITTANCE OF BLACK CHROME AT VARIOUS PLATING TIMES

	Plating time, minutes					
	0.25	0.50	1.0	2.0	4.0	10.0
Average thickness, μ	0.07	0.18	0.5	0.7	1.1	1.3
Absorptance, α	0.64	0.87	0.96	0.96	0.95	0.94
Emittance, ϵ	0.04	0.06	0.10	0.12	0.17	0.34

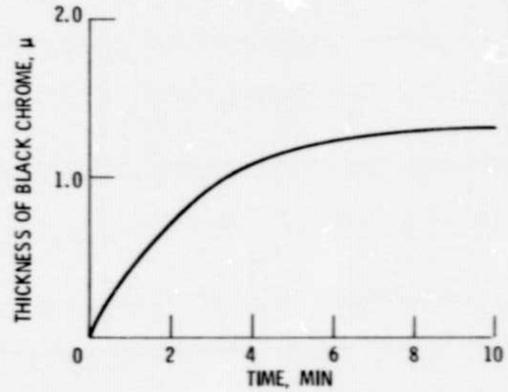

Figure 1. - Thickness of black chrome vs. plating time.

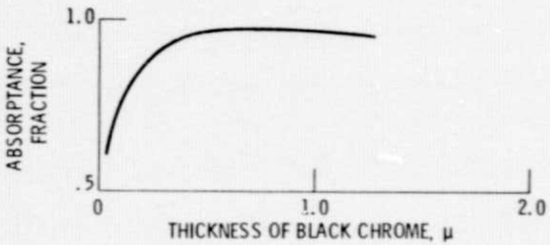

Figure 2. - Absorptance of black chrome vs. thickness.

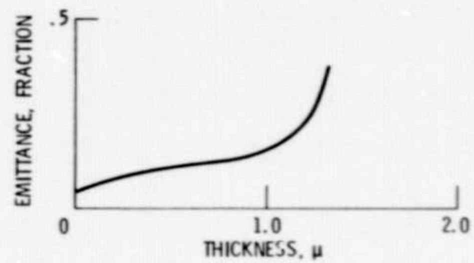

Figure 3. - Emittance of black chrome vs. thickness.